



like a large distribution of magnitudes” generated by a random process, says geophysicist Eric Geist of the U.S. Geological Survey in Menlo Park, California, who doubts that the 2005 quake could have reached this far south to trigger the next one.

Others are more open to a link to the previous rupture. “It’s hard for me to imagine that after 170 years of no [larger-than-magnitude-8] earthquakes, the 2004, 2005, and 2007 earthquakes aren’t somehow involved in triggering”

subsequent earthquakes, says Sieh, who, with colleagues, published a forecast for a post-2005 quake. His Caltech colleague, seismologist Jean-Philippe Avouac, agrees. Stress from the 2005 rupture may have propagated farther but more slowly along the deep parts of the fault to trigger last week’s quake, he says.

However this fault is working, last week’s events are both good news and bad news for people in the region of Padang, says seismologist John McCloskey of the University of

Ulster in Coleraine, U.K. Good news in that the magnitude-8.4 quake relieved some of the stress on the fault; the next quake could be in the low 8s rather than pushing a 9. But bad news in that last week’s activity could only have increased the stress on the segment off Padang, making another rupture more likely. The threat of another huge quake has receded there, says McCloskey, “but in terms of an 8, it’s still the most likely place on the planet.”

—RICHARD A. KERR

Tsunami Warning System Shows Agility—And Gaps in Indian Ocean Network

Within 15 minutes after a magnitude-8.4 earthquake rocked Indonesia’s Sumatra Island last week, tsunami warnings were blaring from mosque loudspeakers in local villages. By then, many residents had already fled. “We tell people that if the shaking is strong, don’t wait for a warning, evacuate,” says Patra Rina Dewi, executive director of the Komunitas Siaga Tsunami (Kogami), a nonprofit in Padang, Indonesia. For several hours after the quake, small tsunamis hit Sumatra’s west coast, causing minor damage but no casualties.

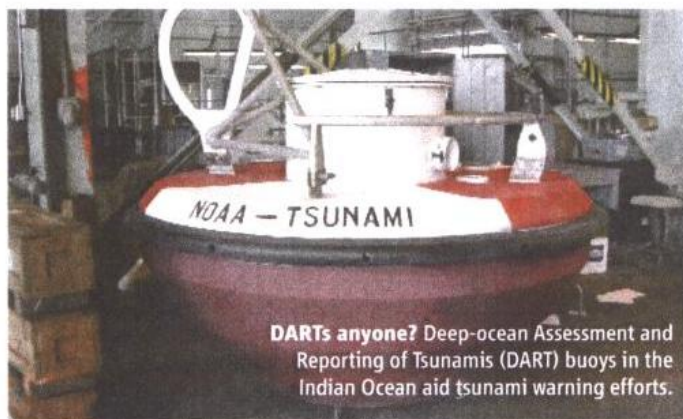
Indonesia’s warning and similar alerts across the region were the fruits of a nascent Indian Ocean Tsunami Warning and Mitigation System. Officials are pleased with the performance of the partly deployed operation, which relies on a network of sensors. But the experience also reinforced the notion that technology is just one facet of a strategy, along with boosting awareness and developing evacuation and response plans.

The need for tsunami preparedness was driven home by the 26 December 2004 magnitude-9.3 earthquake off Sumatra that triggered a monster tsunami. Many of the 230,000 deaths could have been prevented had coastal dwellers been warned of the impending waves.

In response, Indian Ocean nations, buttressed by the United Nations Educational, Scientific and Cultural Organization’s Intergovernmental Oceanographic Commission and donor countries, started stitching together the Tsunami Warning System, a \$130 million network of seismometers, buoys for measuring swells, sea-bottom pressure sensors, and tide gauges, as well as mechanisms for sharing data (*Science*, 9 December 2005, p. 1602). Only a handful of the deep-ocean sensors are in place, and countries are still installing seismometers and tide gauges.

Relying solely on seismic data to determine the magnitude and location of the 12 September earthquake, Indonesia’s Meteorological and Geophysical Agency issued a tsunami warning to authorities near the epicenter “within 5 minutes of the earthquake,” boasts Fauzi, an official in charge of tsunami warnings, who, like many Indonesians, has only a given name. Residents fled low areas on their own initiative—a good response, says Kogami’s Dewi. But she would like to see accurate and timely follow-up advice based on an analysis of sensor data on whether a tsunami is actually on its way. Fauzi says that’s his agency’s goal.

Other countries, with the advantage of distance from the epicenter, were able to forecast the threat more accurately. The Indian Tsunami Warning System, at India’s National Centre for Ocean Information Services in Hyderabad, picked up the quake on its seismometers and put authorities on the



DARTs anyone? Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys in the Indian Ocean aid tsunami warning efforts.

Andaman and Nicobar Islands on alert but stopped short of issuing a warning. After weighing data from tide gauges and recently placed ocean-bottom pressure sensors, the Hyderabad staff concluded that neither the islands nor the mainland faced a tsunami. Three hours after the earthquake, India issued an “all clear.” The network “performed admirably,” says Vinod Menon of the National Disaster Management Authority in New Delhi. But Menon admits that poor communications left people in some coastal regions in a panic. “Messaging and outreach really needs to be fine-tuned,” he says.

Thailand’s National Disaster Warning Center also concluded early on that the chance of a tsunami was small. It alerted officials to stand by but issued no public statements. Smith Dharmasaroja, chair of the National Disaster Warning Administration committee, says the center worried about losing public trust if it broadcast warnings unnecessarily. But many residents heard from the news that warnings had been issued in other countries and evacuated on their own. The center has revised its procedures and, when the next big quake strikes, will issue bulletins to keep the public informed.

Sri Lankan officials, meanwhile, played it safe and evacuated people from areas hardest hit by the 2004 tsunami. Writing in Sri Lanka’s *Sunday Times* on 16 September, Dulip Jayawardene, former director of the Geological Survey Department, called on the government to “train seismologists and geophysicists in interpretation of seismic data” for more accurate tsunami forecasts.

The latest earthquake to rattle South Asia provided “the best drill ever,” says Tavidia Kamolvej, a disaster management expert at Thammasat University in Bangkok. Now, she says, it’s time to find the gaps in the system and fill them.

—DENNIS NORMILE

With reporting by Pallava Bagla.